Negative Feedback, Homeostasis, and Positive Feedback, with Breathing Experiment[1]

Changes in Breathing

1a. You will investigate how your breathing changes as you re-breathe the air in a medium-size plastic trash bag. How do you think your breathing will change after several minutes of breathing into the bag? (Check all that apply.) bigger breaths ___ faster breathing ___ slower breathing ___ smaller breaths ___

1b. Explain your reasoning.

Procedure

A. If you have asthma or some other breathing difficulty, check with your teacher about whether or not you should breathe into a bag. Each person whose health permits should complete steps B and C while other group members observe.

B. To prepare to breathe into your 8-gallon plastic trash bag, open the bag completely and swish it through the air until the bag is nearly full of air. Then, gather the top of the bag in both hands, and open a small hole in the center just big enough to surround your nose and mouth. To make a good seal, hold this opening tightly over your nose and mouth.

C. Breathe into your bag for 4 minutes (or as long as you can). Breathe as normally as you can. Notice any changes in breathing rate (number of breaths per minute) and volume of each breath (the amount of air taken in with each breath).

If you are observing another member of your group, watch how a crease in the bag changes as the person breathes in and out. This will help you to notice any changes in breathing rate and/or volume of each breath. Record your observations in question 2.

Results and Analysis

2a. Describe how your breathing changed as you re-breathed the air in the bag for several minutes. Include any changes in breathing rate and/or volume of each breath.

2b. Describe how breathing changed for each of the other subjects in your group.

Subject Name	Changes in Breathing Rate and/or Volume of Each Breath

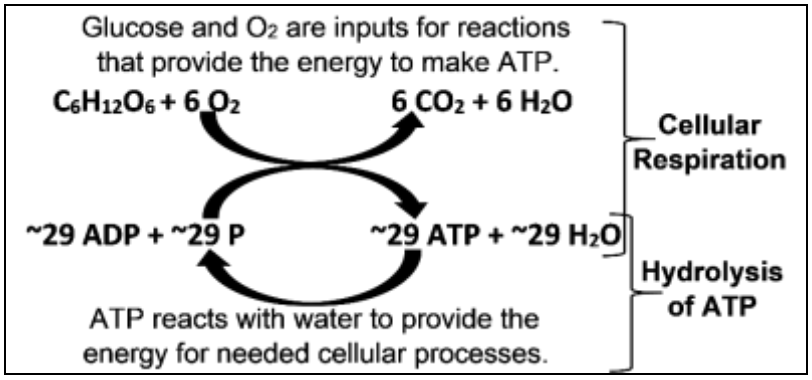
3a. Summarize the overall pattern of changes in breathing rate and volume of each breath.

3b. What do you think caused these changes in breathing?

Questions 4-9 will help you to understand the reasons for the changes in breathing you have observed.

4a. Circle the two gases in this figure.

4b. Why do you need to keep breathing all day and all night?



5. The statements below describe how O_2 moves from the air in your lungs to the cells in your body. Write the letter of each statement next to the part of the figure that the statement describes.

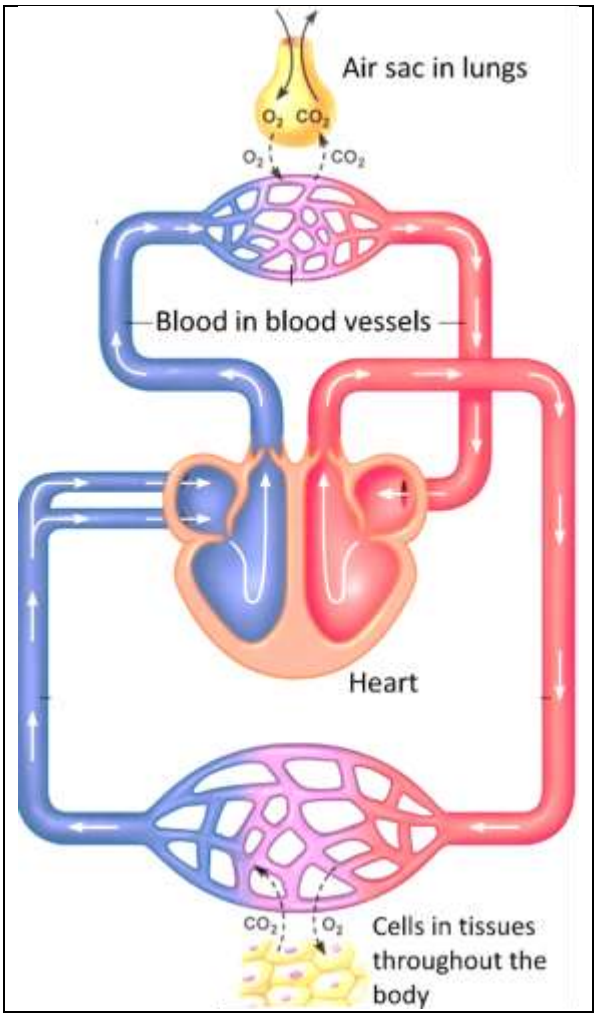
a. In your lungs there are millions of tiny air sacs, each surrounded by many tiny blood vessels. O_2 diffuses from the air in the air sacs to the blood in the surrounding tiny blood vessels.

b. Your blood carries O_2 from your lungs to your heart.

c. Your heart pumps your O_2-carrying blood throughout your body.

d. Your O_2-carrying blood flows through tiny blood vessels near every cell in your body.

e. O_2 diffuses from your blood into your cells.



6a. Draw a long arrow that shows how the CO_2 produced by your body's cells gets to the air sacs in your lungs.

6b. How is the CO_2 in the air sacs in your lungs removed from your body?

7a. Compared to the air you breathe in, the air you breathe out has _____ O_2.
(less / more)

7b. Compared to the air you breathe in, the air you breathe out has _____ CO_2.
(less / more)

8. As you re-breathed the air in the bag over and over again:

- what happened to the level of O_2 in the air in the bag? decreased ___ increased ___
- what happened to the level of CO_2 in the air in the bag? decreased ___ increased ___

9a. If there were no change in your breathing rate or the volume of each breath while you re-breathed the air in the bag over and over again:

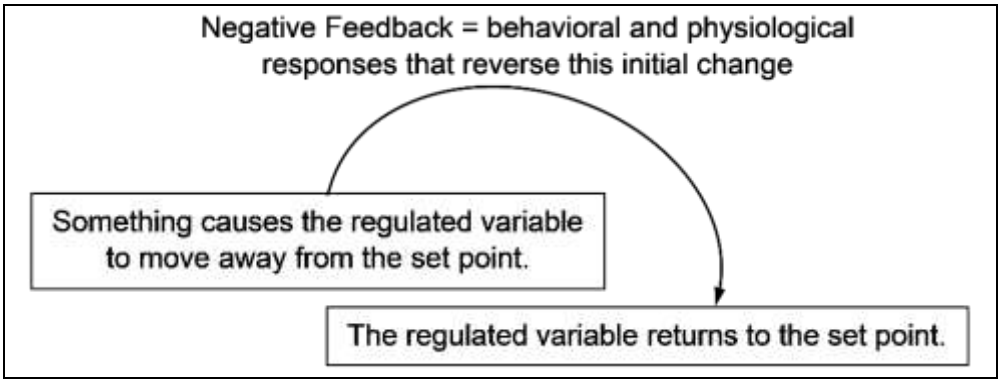
- what would happen to the levels of O_2 in your blood? decrease ___ increase ___
- what would happen to the levels of CO_2 in your blood? decrease ___ increase ___

(Hint: Check your answers to question 8.)

9b. What changes in breathing could bring more O_2 into your lungs?

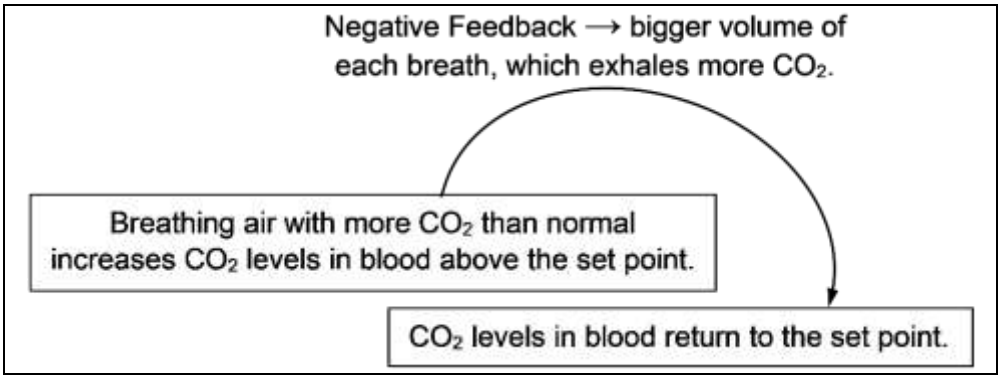
9c. As your group members re-breathed the air in the bag, how did the changes in breathing help to prevent decreases in blood levels of O_2?

The changes in breathing that maintained high enough blood levels of O_2 and prevented excessive accumulation of CO_2 are an example of **negative feedback**. Negative feedback keeps a regulated variable (e.g. blood levels of O_2 or CO_2) near a set point.



10. Complete this sentence to describe how negative feedback keeps a regulated variable near its set point.

When anything causes a regulated variable to move away from its set point, negative feedback _____ the initial change, which brings the regulated variable back to the _____.



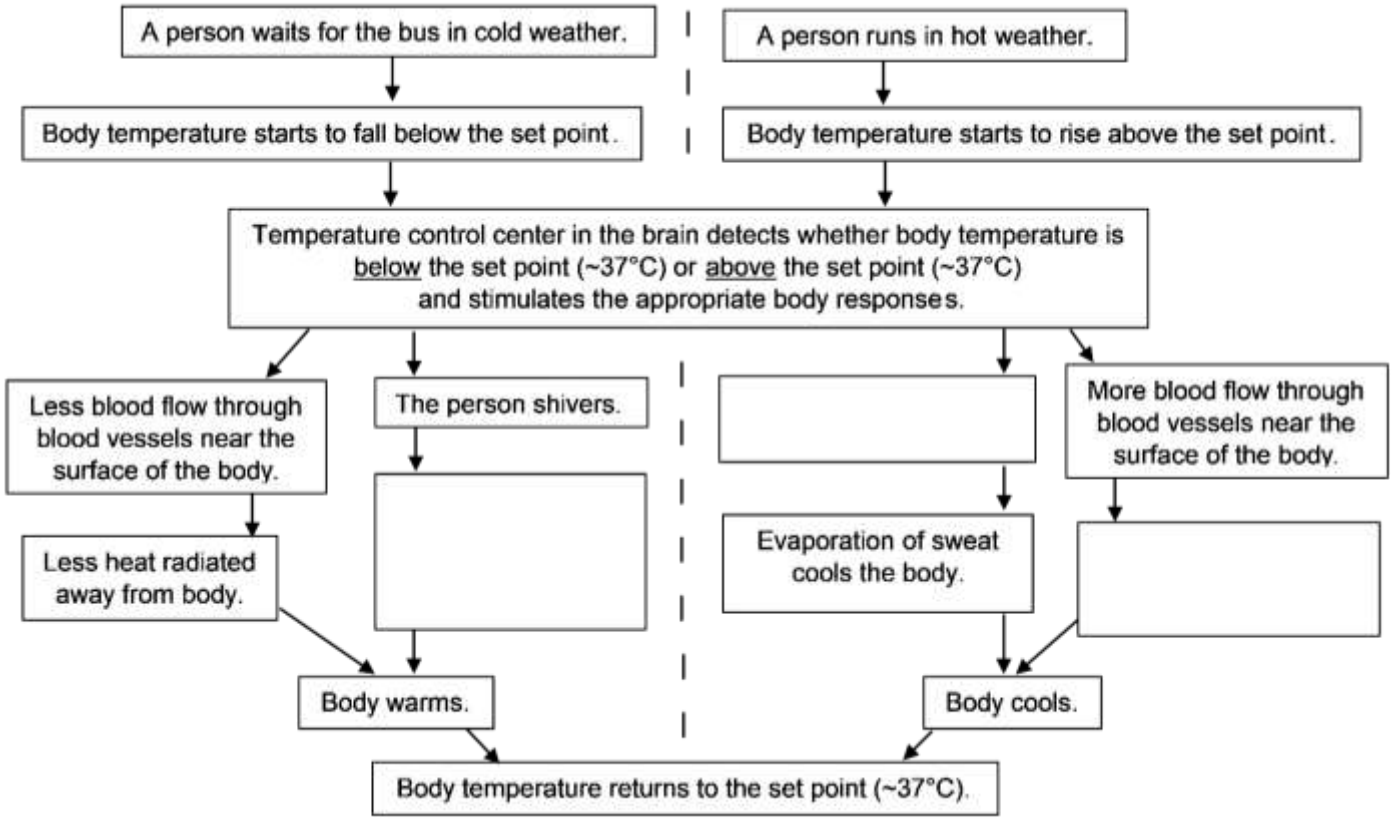
11a. In this diagram, what is the regulated variable?

11b. Underline the changes in breathing that keep CO_2 levels in the blood from rising too high.

Negative Feedback Regulation of Body Temperature

Negative feedback maintains body temperature within an optimum range, even when the external environment gets colder or hotter. Part of your brain functions as a temperature control center. Usually, the set point for body temperature regulation is approximately 37°C (~37°C = ~98.6°F). If your body temperature starts to fall below ~37°C or increase above ~37°C, then the temperature control center triggers responses that bring your body temperature back to the set point (~37°C).

12. Complete this flowchart to show how a person's temperature control center keeps body temperature close to 37° C.



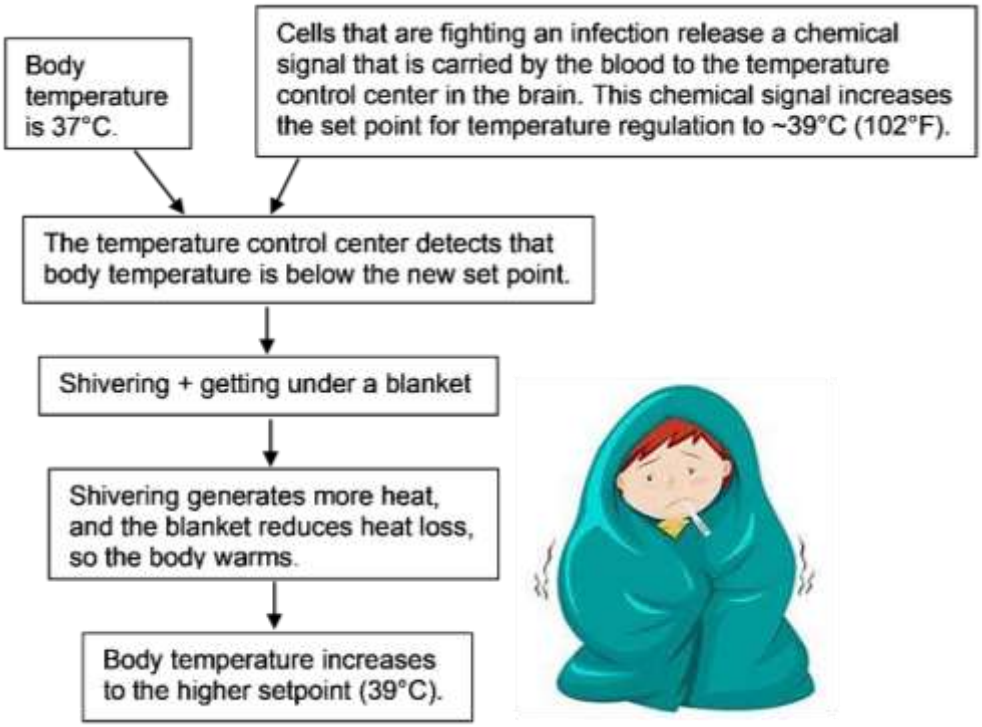
13a. What could go wrong if your body temperature got too low?

13b. What could go wrong if your body temperature got too high?

Thus far, you have seen that your body maintains a relatively constant body temperature and your body maintains relatively constant levels of CO_2 and O_2 in your blood. Your body also keeps other internal conditions in an optimum range. This maintenance of relatively constant internal conditions is called **homeostasis**.

14. Explain how negative feedback contributes to homeostasis.

Homeostasis and negative feedback do *not* mean that body temperature is always constant. For example, when you have an infection, you may develop a fever (i.e., your body temperature increases). Your higher body temperature helps your immune system fight the infection. This flowchart shows how a person who has an infection develops a fever.



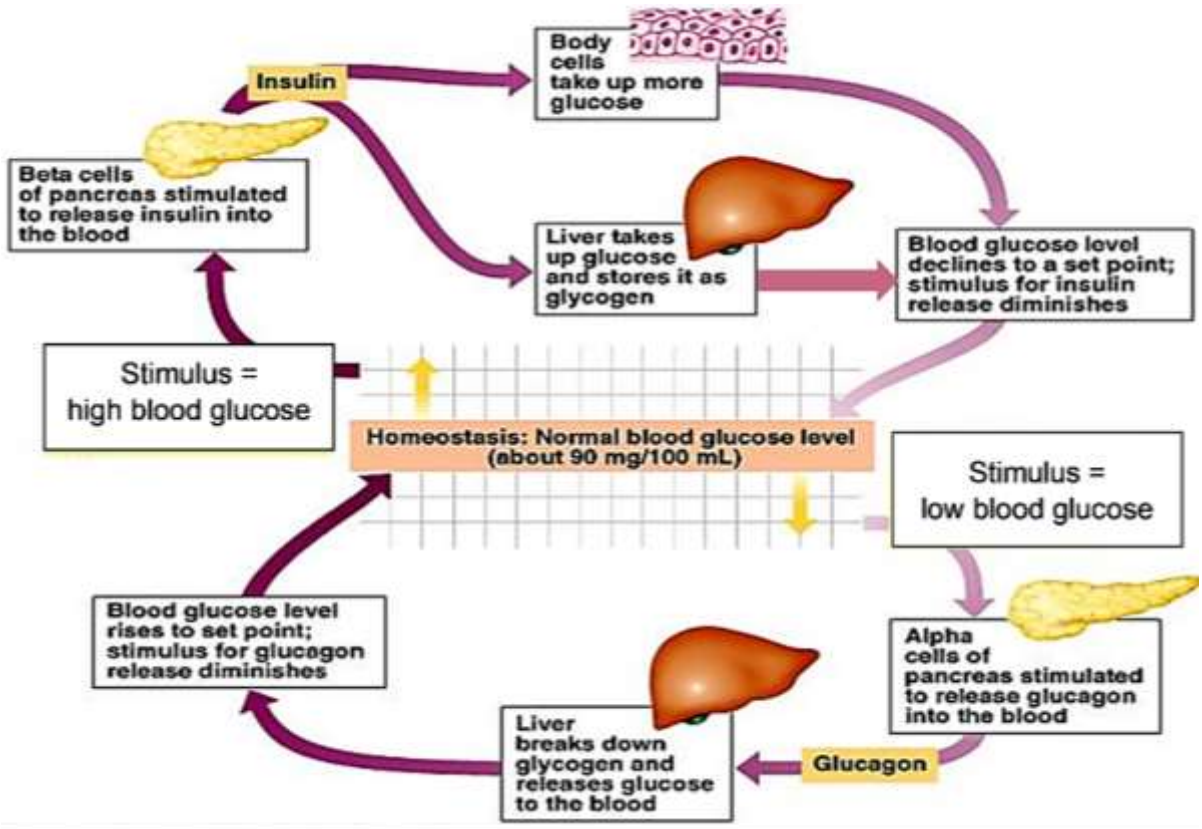
15. Notice that the person described in this flowchart is shivering, even though his body temperature is at the normal set point (37°C). Explain why he is shivering.

Diabetes – A Failure of Negative Feedback Regulation of Blood Glucose Levels

When negative feedback doesn't work correctly, this can result in illness. For example, defects in negative feedback regulation of blood glucose levels can result in diabetes. In a person with diabetes, too much glucose in the blood injures blood vessels and nerves, which can cause heart disease, kidney disease, stroke, and/or blindness.

16. Negative feedback keeps blood glucose levels near an optimum. What problems could result if a person's blood glucose levels get too low, so the person's cells do not get enough glucose?

The figure on the next page shows normal negative feedback regulation that prevents blood glucose levels from rising too high or falling too low.



17a. When blood glucose levels are high, excess glucose is stored in <u>glycogen</u>, which is a polymer of glucose. Write polymer next to glycogen in the figure.

17b. <u>Insulin</u> and <u>glucagon</u> are hormones, which are chemical messengers that travel in the blood. Write hormone next to insulin and glucagon in the figure.

18a. After a person eats a meal, glucose is absorbed from the gut into the blood, so blood glucose levels begin to rise. Describe the physiological responses that prevent an excessive rise in blood glucose levels after a meal.

18b. When a person has not eaten for a long time, what physiological responses help to prevent blood glucose levels from falling too low?

19a. In a person with type 1 diabetes, the pancreas produces little or no insulin. Cross out the parts of the above figure that would not occur in a person who produces no insulin.

19b. The lack of insulin results in blood glucose levels that are _____ than normal.
(higher/lower)

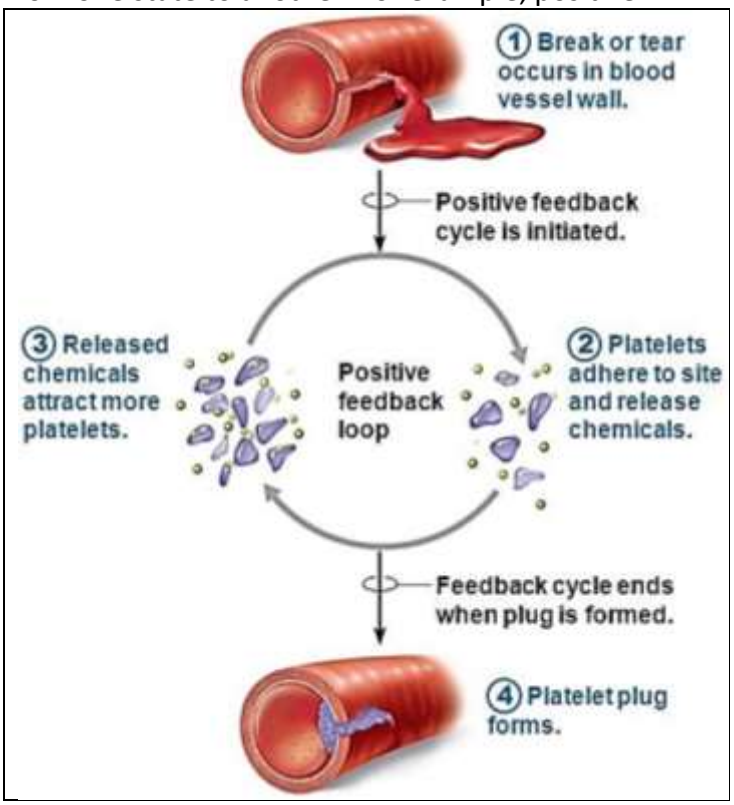
19c. Type 2 diabetes begins with insulin resistance – when a given amount of insulin has less effect than normal. To describe type 2 diabetes, fill in the blanks in this chart.

Insulin resistance = For a given amount of insulin, the person's cells (including liver cells) take up less glucose from the blood.	→ Increased blood glucose levels	→ The person's pancreas secretes more _____, but eventually the pancreas cannot secrete enough insulin.	→ Blood glucose levels are _____ than normal.

Positive feedback produces rapid change.

In **positive feedback**, an initial change stimulates more change in the same direction. Therefore, positive feedback produces rapid change from one state to another. For example, positive feedback contributes to a rapid transition from an injured blood vessel (which allows blood to leak out) to a platelet plug (which stops the blood from leaking out).

- Blood contains platelets, which stick to the injured part of the blood vessel.
- When platelets stick to the injured area, they begin to secrete chemical signals that attract more platelets.
- Many platelets accumulate quickly and plug the hole in the injured blood vessel.
- Once the hole is plugged, different chemical signals prevent further platelet accumulation.



20. Explain how positive feedback helps to prevent excessive blood loss after a blood vessel has been injured.

21. In some basic ways, positive feedback is the opposite of negative feedback. To illustrate this, fill in each blank in this table.

Positive Feedback		Negative Feedback
An initial change stimulates more change in the _____ direction.		An initial change away from the set point stimulates a response that _____ the initial change.
Positive feedback results in _____.		Negative feedback keeps a regulated variable (e.g., body temperature) _____.

22a. If you are cold, shivering can increase your body temperature. Is shivering part of positive feedback ___? negative feedback ___?

22b. Explain your reasoning.

23. Explain why positive feedback and negative feedback are appropriate names for these two different types of feedback.